

Serial No. 09/618,326

Amendment and Response Dated December 31, 2003

Reply to Office Action Dated December 1, 2002

**AMENDMENTS TO THE CLAIMS:**

This listing of claims will replace all prior versions, and listings, of claims in the application.

**In the claims:**

1. (Original) An image-sensing apparatus comprising:

a photoelectric conversion portion having a photosensitive element producing an electric signal in accordance with amount of incident light and a first transistor having a first electrode connected to the photosensitive element, a second electrode, and a control electrode, the photoelectric conversion portion outputting the electric signal output from the photosensitive element and converted natural-logarithmically by making the first transistor operate in a subthreshold region;

a lead-out path by way of which the electric signal output from the photoelectric conversion portion is fed to an output signal line; and

a controller for resetting a potential in the first transistor by switching a voltage applied to the control electrode of the first transistor.

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2. (Original) An image-sensing apparatus as claimed in claim 1, further comprising:

an integrator circuit for integrating the electric signal output from the photoelectric conversion portion, the electric signal integrated by the integrator circuit being fed by way of the lead-out path to the output signal line.

3. (Original) An image-sensing apparatus as claimed in claim 2, further comprising;

a resetting portion,

wherein, after the electric signal integrated by the integrator circuit is fed to the output signal line, the controller makes the resetting portion discharge an electric charge accumulated in the integrator circuit.

4. (Original) An image-sensing apparatus as claimed in claim 3, wherein the resetting portion comprises a resetting transistor having a first electrode connected to the integrator circuit, a second electrode, and a control electrode, wherein the controller discharges the electric charge accumulated in the integrator circuit by varying a voltage level applied to the control electrode of the resetting transistor so as to bring the resetting transistor into a conducting state.

5. (Original) An image-sensing apparatus comprising:  
a photoelectric conversion portion that outputs an electric signal produced in accordance with amount of incident light and converted natural-logarithmically, the photoelectric conversion portion comprising:

a photosensitive element having a first electrode to which a direct-current voltage is applied and a second electrode;

a first transistor having a first electrode connected to the second electrode of the photosensitive element, a second electrode to which a direct-current voltage is applied, and a control electrode, the first transistor receiving a current output from the photosensitive element; and

a second transistor having a first electrode to which a direct-current voltage is applied, a second electrode from which an electric signal is output, and a control electrode connected to the first electrode of the first transistor;

a lead-out path by way of which the electric signal output from the photoelectric conversion portion is fed to the output signal line;

a resetting capacitor having one end connected to the control electrode of the first transistor; and

a controller that performs image sensing by applying a first voltage to the other end of the resetting capacitor so as to make the first transistor operate in a subthreshold region below a threshold value thereof,

wherein the controller resets the first transistor by switching the voltage applied to the other end of the resetting capacitor from the first voltage to a second voltage so as to vary a voltage at the control electrode of the first transistor and thereby injecting an

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electric charge having an opposite polarity to a photoelectric charge accumulated by the photoelectric conversion portion so that the accumulated photoelectric charge recombines with the injected electric charge, and thereafter switches the voltage applied to the other end of the resetting capacitor from the second voltage back to the first voltage.

6. (Original) An image-sensing apparatus as claimed in claim 5,  
wherein the control electrode of the first transistor is connected to the first  
electrode thereof.

7. (Original) An image-sensing apparatus as claimed in claim 5, further  
comprising:

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an integrator circuit for integrating the electric signal output from the photoelectric conversion portion, the electric signal integrated by the integrator circuit being fed by way of the lead-out path to the output signal line.

8. (Original) An image-sensing apparatus as claimed in claim 7, further  
comprising;

a resetting portion,  
wherein, after the electric signal integrated by the integrator circuit is fed to the output signal line, the controller makes the resetting portion discharge an electric charge accumulated in the integrator circuit.

9. (Original) An image-sensing apparatus as claimed in claim 8,  
wherein the resetting portion comprises a resetting transistor having a first  
electrode connected to the integrator circuit, a second electrode, and a control electrode,  
wherein the controller discharges the electric charge accumulated in the integrator circuit by varying a voltage level applied to the control electrode of the resetting transistor so as to bring the resetting transistor into a conducting state.

10. (Original) An image-sensing apparatus comprising:  
a photoelectric conversion portion that outputs an electric signal produced in

accordance with amount of incident light and converted natural-logarithmically, the photoelectric conversion portion comprising:

a photosensitive element having a first electrode to which a direct-current voltage is applied and a second electrode;

a first transistor having a first electrode connected to the second electrode of the photosensitive element, a second electrode to which a direct-current voltage is applied, and a control electrode, the first transistor receiving a current output from the photosensitive element; and

a second transistor having a first electrode to which a direct-current voltage is applied, a second electrode from which an electric signal is output, and a control electrode connected to the first electrode of the first transistor;

a lead-out path by way of which the electric signal output from the photoelectric conversion portion is fed to the output signal line;

a resetting capacitor having one end connected to the control electrode of the first transistor;

a switch connected between the control electrode and the first electrode of the first transistor; and

a controller that performs image sensing by turning on the switch and applying a first voltage to the other end of the resetting capacitor so as to make the first transistor operate in a subthreshold region below a threshold value thereof,

wherein the controller resets the first transistor by switching the voltage applied to the other end of the resetting capacitor from the first voltage to a second voltage so as to vary a voltage at the control electrode of the first transistor and thereby injecting an electric charge having an opposite polarity to a photoelectric charge accumulated by the photoelectric conversion portion, and thereafter switches the voltage applied to the other end of the resetting capacitor from the second voltage back to the first voltage.

11. (Original) An image-sensing apparatus as claimed in claim 10, further comprising:

a plurality of pixels each including the photoelectric conversion portion, the lead-

out path, the resetting capacitor, and the switch,

wherein the controller detects variations in sensitivity of the individual pixels by, in each pixel, turning off the switch and varying the direct-current voltage applied to the second electrode of the first transistor so that an electric charge is injected into the first transistor via the second electrode thereof.

12. (Original) An image-sensing apparatus as claimed in claim 10,  
wherein the switch is composed of a transistor.

13. (Original) An image-sensing apparatus as claimed in claim 10, further comprising:

a plurality of pixels each including the photoelectric conversion portion, the lead-out path, the resetting capacitor, and the switch, the pixels being arranged in a matrix.

14. (Original) An image-sensing apparatus as claimed in claim 10, further comprising:

an integrator circuit for integrating the electric signal output from the photoelectric conversion portion, the electric signal integrated by the integrator circuit being fed by way of the lead-out path to the output signal line.

15. (Original) An image-sensing apparatus as claimed in claim 14, further comprising;

a resetting portion,

wherein, after the electric signal integrated by the integrator circuit is fed to the output signal line, the controller makes the resetting portion discharge an electric charge accumulated in the integrator circuit.

16. (Original) An image-sensing apparatus as claimed in claim 15,  
wherein the resetting portion comprises a resetting transistor having a first electrode connected to the integrator circuit, a second electrode, and a control electrode,  
wherein the controller discharges the electric charge accumulated in the integrator

circuit by varying a voltage level applied to the control electrode of the resetting transistor so as to bring the resetting transistor into a conducting state.

17. (Original) An image-sensing apparatus as claimed in claim 10, further comprising:

a plurality of pixels each including the photoelectric conversion portion, the lead-out path, the resetting capacitor, and the switch, the pixels each further including an amplifying transistor for amplifying the electric signal output from the photoelectric conversion portion, the electric signal amplified by the amplifying transistor being fed by way of the lead-out path to the output signal line.

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18. (Original) An image-sensing apparatus as claimed in claim 17, further comprising:

load resistors or constant-current sources connected to the output signal line, a total number of the load resistors or constant-current sources being smaller than a total number of the pixels.

19. (Original) An image-sensing apparatus as claimed in claim 18, wherein the load resistors or constant-current sources each comprise a resistive transistor having a first electrode connected to the output signal line and a second electrode and a control electrode connected to a direct-current voltage.

20. (Original) An image-sensing apparatus as claimed in claim 19, wherein the amplifying transistor is an N-channel MOS transistor, and wherein a direct-current voltage applied to a first electrode of the amplifying transistor is higher than the direct-current voltage applied to the second electrode of the resistive transistor.

21. (Original) An image-sensing apparatus as claimed in claim 19, wherein the amplifying transistor is a P-channel MOS transistor, and wherein a direct-current voltage applied to a first electrode of the amplifying

transistor is lower than the direct-current voltage applied to the second electrode of the resistive transistor.

22. (Original) An image-sensing apparatus as claimed in claim 10, further comprising:

a plurality of pixels each including the photoelectric conversion portion, the lead-out path, the resetting capacitor, and the switch,

wherein the lead-out path includes a switch that selects one after another of the pixels in a predetermined sequence and feeds the signal output from the selected pixel to the output signal line.

23. (Original) An image-sensing apparatus comprising:  
a plurality of pixels, the pixels each including:

a photodiode, having two electrodes, that produces an electric signal in accordance with amount of incident light;

a first MOS transistor having a first electrode, a second electrode, and a gate electrode, the first and gate electrodes of the first MOS transistor connected to one electrode of the photodiode;

a second MOS transistor having a first electrode, a second electrode, and a gate electrode connected to the first and gate electrodes of the first MOS transistor; and

a first capacitor having one end connected to the gate electrode of the first MOS transistor; and

a controller that makes the individual pixels perform image sensing in such a way that the electric signal output from the photodiode is converted natural-logarithmically by feeding a first voltage to the first capacitor so as to make the first MOS transistor operate in a subthreshold region below a threshold value thereof,

wherein the controller resets the individual pixels by feeding a second voltage to the first capacitor and thereby varying a potential in the first MOS transistor so as to permit recombination of a photoelectric charge fed from the photodiode and accumulated in the first MOS transistor.

24. (Original) An image-sensing apparatus as claimed in claim 23,  
wherein the pixels each further include a third MOS transistor provided between  
the first and gate electrodes of the first MOS transistor and having a first electrode  
connected to the first electrode of the first MOS transistor, a second electrode connected to  
the gate electrode of the first MOS transistor, and a gate electrode, and

wherein the controller detects variations in the threshold value of the first MOS  
transistor by bringing the third MOS transistor into a non-conducting state, feeding the  
second voltage to the first capacitor, and varying a voltage applied to the second electrode  
of the first MOS transistor so that an electric charge is injected into the first MOS  
transistor via the second electrode thereof.

25. (Original) An image-sensing apparatus as claimed in claim 23,  
wherein the pixels each further include a fifth MOS transistor having a first  
electrode connected to the second electrode of the second MOS transistor, a second  
electrode connected to an output signal line, and a gate electrode connected to a line select  
line.

26. (Original) An image-sensing apparatus as claimed in claim 23,  
wherein the pixels each further include a fourth MOS transistor having a first  
electrode to which a direct-current voltage is applied, a second electrode, and a gate  
electrode connected to the second electrode of the second MOS transistor, the fourth  
transistor amplifying a signal output from the second electrode of the second MOS  
transistor.

27. (Original) An image-sensing apparatus as claimed in claim 26,  
wherein the pixels each further include a fifth MOS transistor having a first  
electrode connected to the second electrode of the fourth MOS transistor, a second  
electrode connected to an output signal line, and a gate electrode connected to a line select  
line.

28. (Original) An image-sensing apparatus as claimed in claim 26, wherein the pixels each further include a second capacitor having one end connected to the second electrode of the second MOS transistor, the second capacitor being reset through the second MOS transistor when a reset voltage is fed to the first electrode of the second MOS transistor.

29. (Original) An image-sensing apparatus as claimed in claim 26, wherein the second MOS transistor receives a direct-current voltage at the first electrode thereof, and

wherein the pixels each further include:

a sixth MOS transistor having a first electrode connected to the second electrode of the second MOS transistor, a second electrode connected to a direct-current voltage, and a gate electrode; and

a second capacitor having one end connected to the second electrode of the second MOS transistor, the second capacitor being reset through the sixth MOS transistor when a reset voltage is fed to the gate electrode of the sixth MOS transistor.

30. (Original) An image-sensing apparatus as claimed in claim 23, further comprising:

MOS transistors connected to the individual pixels by way of output signal lines so as to serve as load resistors or constant-current sources.

31. (Original) An image-sensing apparatus comprising:

a photoelectric conversion portion having a photosensitive element producing an electric signal in accordance with amount of incident light and a first transistor having a first electrode connected to the photosensitive element, a second electrode, and a control electrode, the photoelectric conversion portion outputting the electric signal output from the photosensitive element and converted natural-logarithmically by making the first transistor operate in a subthreshold region;

a lead-out path by way of which the electric signal output from the photoelectric

conversion portion is fed to an output signal line; and

a controller that performs image sensing by feeding a first voltage to the second electrode of the first transistor so as to make the first transistor operate in the subthreshold region,

wherein the controller, by feeding a second voltage to the second electrode of the first transistor, permits a larger current to flow through the first transistor than before feeding the second voltage thereto.

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32. (Original) An image-sensing apparatus as claimed in claim 31, further comprising:

an integrator circuit for integrating the electric signal output from the photoelectric conversion portion, the electric signal integrated by the integrator circuit being fed by way of the lead-out path to the output signal line.

33. (Original) An image-sensing apparatus as claimed in claim 32, further comprising;

a resetting portion,

wherein, after the electric signal integrated by the integrator circuit is fed to the output signal line, the controller makes the resetting portion discharge an electric charge accumulated in the integrator circuit.

34. (Original) An image-sensing apparatus as claimed in claim 33, wherein the resetting portion comprises a resetting transistor having a first electrode connected to the integrator circuit, a second electrode, and a control electrode,

wherein the controller discharges the electric charge accumulated in the integrator circuit by varying a voltage level applied to the control electrode of the resetting transistor so as to bring the resetting transistor into a conducting state.

35. (Original) An image-sensing apparatus comprising:  
a plurality of pixels, the pixels each including a photoelectric conversion portion that outputs an electric signal produced in accordance with amount of incident light and

converted natural-logarithmically and a lead-out path by way of which the electric signal output from the photoelectric conversion portion is fed to the output signal line, the photoelectric conversion portion comprising:

a photosensitive element having a first electrode to which a direct-current voltage is applied and a second electrode;

a first transistor having a first electrode and a control electrode connected to the second electrode of the photosensitive element and a second electrode, the first transistor receiving a current output from the photosensitive element; and

a second transistor having a first electrode to which a direct-current voltage is applied, a second electrode from which an electric signal is output, and a control electrode connected to the first and control electrodes of the first transistor; and

a controller that performs image sensing by feeding a first voltage to the second electrode of the first transistor so as to make the first transistor operate in a subthreshold region below a threshold value thereof,

wherein the controller resets the individual pixels by, in each pixel, feeding a second voltage to the second electrode of the first transistor so as to permit a larger current to flow through the first transistor than before feeding the second voltage thereto.

36. (Original) An image-sensing apparatus as claimed in claim 35,  
wherein the pixels are arranged in a matrix.

37. (Original) An image-sensing apparatus as claimed in claim 35, further comprising:

an integrator circuit for integrating the electric signal output from the photoelectric conversion portion, the electric signal integrated by the integrator circuit being fed by way of the lead-out path to the output signal line.

38. (Original) An image-sensing apparatus as claimed in claim 37, further comprising;

a resetting portion,

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wherein, after the electric signal integrated by the integrator circuit is fed to the output signal line, the controller makes the resetting portion discharge an electric charge accumulated in the integrator circuit.

39. (Original) An image-sensing apparatus as claimed in claim 38,  
wherein the resetting portion comprises a resetting transistor having a first electrode connected to the integrator circuit, a second electrode, and a control electrode,  
wherein the controller discharges the electric charge accumulated in the integrator circuit by varying a voltage level applied to the control electrode of the resetting transistor so as to bring the resetting transistor into a conducting state.

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40. (Original) An image-sensing apparatus as claimed in claim 35,  
wherein the pixels each further include an amplifying transistor for amplifying the electric signal output from the photoelectric conversion portion, the electric signal amplified by the amplifying transistor being fed by way of the lead-out path to the output signal line.

41. (Original) An image-sensing apparatus as claimed in claim 40, further comprising:

load resistors or constant-current sources connected to the output signal line, a total number of the load resistors or constant-current sources being smaller than a total number of the pixels.

42. (Original) An image-sensing apparatus as claimed in claim 41,  
wherein the load resistors or constant-current sources each comprise a resistive transistor having a first electrode connected to the output signal line and a second electrode and a control electrode connected to a direct-current voltage.

43. (Original) An image-sensing apparatus as claimed in claim 42,  
wherein the amplifying transistor is an N-channel MOS transistor, and  
wherein a direct-current voltage applied to a first electrode of the amplifying

transistor is higher than the direct-current voltage applied to the second electrode of the resistive transistor.

44. (Original) An image-sensing apparatus as claimed in claim 42, wherein the amplifying transistor is a P-channel MOS transistor, and wherein a direct-current voltage applied to a first electrode of the amplifying transistor is lower than the direct-current voltage applied to the second electrode of the resistive transistor.

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45. (Original) An image-sensing apparatus as claimed in claim 35, wherein the lead-out path includes a switch that selects one after another of the pixels in a predetermined sequence and feeds the signal output from the selected pixel to the output signal line.

46. (Original) An image-sensing apparatus comprising:  
a plurality of pixels, the pixels each including:  
a photodiode, having two electrodes, that produces an electric signal in accordance with amount of incident light;  
a first MOS transistor having a first electrode and a gate electrode connected to one electrode of the photodiode and a second electrode; and  
a second MOS transistor having a first electrode, a second electrode, and a gate electrode connected to the first and gate electrodes of the first MOS transistor; and  
a controller that makes the individual pixels perform image sensing in such a way that the electric signal output from the photodiode is converted natural-logarithmically by feeding a first voltage to the second electrode of the first MOS transistor so as to make the first MOS transistor operate in a subthreshold region below a threshold value thereof,  
wherein the controller resets the individual pixels by, in each pixel, feeding a second voltage to the second electrode of the first MOS transistor so as to permit a larger

current to flow through the first MOS transistor than before feeding the second voltage thereto.

47. (Original) An image-sensing apparatus as claimed in claim 46, wherein the pixels each further include a fourth MOS transistor having a first electrode connected to the second electrode of the second MOS transistor, a second electrode connected to an output signal line, and a gate electrode connected to a line select line.

48. (Original) An image-sensing apparatus as claimed in claim 46, wherein the pixels each further include a third MOS transistor having a first electrode to which a direct-current voltage is applied, a second electrode, and a gate electrode connected to the second electrode of the second MOS transistor, the third MOS transistor amplifying a signal output from the second electrode of the second MOS transistor.

49. (Original) An image-sensing apparatus as claimed in claim 48, wherein the pixels each further include a fourth MOS transistor having a first electrode connected to the second electrode of the third MOS transistor, a second electrode connected to an output signal line, and a gate electrode connected to a line select line.

50. (Original) An image-sensing apparatus as claimed in claim 48, wherein the pixels each further include a capacitor having one end connected to the second electrode of the second MOS transistor, the capacitor being reset through the second MOS transistor when a reset voltage is fed to the first electrode of the second MOS transistor.

51. (Original) An image-sensing apparatus as claimed in claim 48, wherein the second MOS transistor receives a direct-current voltage at the first electrode thereof, and wherein the pixels each further include:

a fifth MOS transistor having a first electrode connected to the second electrode of the second MOS transistor, a second electrode to which a direct-current voltage is applied, and a gate electrode; and

a capacitor having one end connected to the second electrode of the second MOS transistor, the capacitor being reset through the fifth MOS transistor when a reset voltage is fed to the gate electrode of the fifth MOS transistor.

52. (Original) An image-sensing apparatus as claimed in claim 46, further comprising:

MOS transistors connected to the individual pixels by way of output signal lines so as to serve as load resistors or constant-current sources.

53. (New) An image-sensing apparatus as claimed in claim 2, further comprising:

a transistor disposed in said lead-out path for controlling a feed of the electric signal output from the photoelectric conversion portion to said output signal line; and

a transistor disposed in said lead-out path for amplifying the electric signal output from the photoelectric conversion portion, a thus amplified electric signal being fed by way of the lead-out path to the output signal line.

54. (New) An image-sensing apparatus as claimed in claim 32, further comprising:

a transistor disposed in said lead-out path for controlling a feed of the electric signal output from the photoelectric conversion portion to said output signal line; and

a transistor disposed in said lead-out path for amplifying the electric signal output from the photoelectric conversion portion, a thus amplified electric signal being fed by way of the lead-out path to the output signal line.

55. (New) An image-sensing apparatus as claimed in claim 40, wherein the pixels each further comprise:

a transistor connected between the second transistor and an output signal line; and

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an integrator circuit for integrating the electric signal output from the photoelectric conversion portion, the electric signal integrated by the integrator circuit being fed by way of the lead-out path to the output signal line.

56. (New) An image-sensing apparatus as claimed in claim 49, wherein the pixels each further comprise:

a capacitor having one end connected to the second electrode of the second MOS transistor, the capacitor being reset through the second MOS transistor when a reset voltage is fed to the first electrode of the second MOS transistor.

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